U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
A. C. TRUE, Director.

ORGANIZATION AND WORK

OF

AGRICULTURAL EXPERIMENT STATIONS IN THE UNITED STATES.

BY

DICK J. CROSBY,
Of the Office of Experiment Stations.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., May 27, 1904.

Sir: I have the honor to transmit herewith and recommend for publication a brief general account of the organization and work of the agricultural experiment stations in the United States, including also brief statements regarding the income, equipment, and result of the work of these stations. This article has been prepared by Dick J. Crosby for distribution at the Louisiana Purchase Exposition in St. Louis.

Respectfully,

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

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ORGANIZATION AND WORK OF AGRICULTURAL EXPERIMENT STATIONS IN THE UNITED STATES.[a]

By Dick J. Crosby,
Of the Office of Experiment Stations.

ORGANIZATION OF THE STATIONS.

The agricultural experiment stations in the United States are State institutions supported in part by funds given by the National Government to the States to be used for their maintenance. The direct management of the stations is wholly in the hands of State officers, but they sustain certain definite relations to the Federal Government, and the Congressional appropriations for their support are included in the annual appropriation acts for the United States Department of Agriculture. The money thus appropriated is paid to the stations quarterly in advance by the United States Treasury. Regulations governing the use of the franking privilege by the stations are made by the Post-Office Department. As departments of the colleges receiving the benefits of the land-grant act of 1862, reports of the stations are annually sent to the Secretary of the Interior, who is represented in his relations with these institutions by the Bureau of Education.

The stations have much more intimate relations with the Department of Agriculture than with any other branch of the Federal Government. The act of Congress (Hatch Act) of March 2, 1887, under which the stations have been organized, provides "that in order to secure, as far as practicable, uniformity of methods and results in the work of said stations it shall be the duty of the United States Commissioner (now Secretary) of Agriculture to furnish forms, as far as practicable, for the tabulation of results of investigations or experiments; to indicate from time to time such lines of inquiry as to him shall seem most important, and in general to furnish such advice and assistance as will best promote the purposes of this act." In accordance with this provision, the Office of Experiment Stations was established in 1888 to represent the Secretary of Agriculture in his relations with the stations.

[a] Adapted and brought up to date from Office of Experiment Stations Bul. 80, pp. 45–78.

Beginning with the year 1894, Congress has each year inserted in the appropriation act for the maintenance of the stations a provision that "the Secretary of Agriculture shall prescribe the form of the annual financial statement [required by the Hatch Act], shall ascertain whether the expenditures under the appropriation hereby made are in accordance with the provisions of said act, and shall report thereon to Congress." Thus, virtually, the Secretary of Agriculture now has general supervision of the expenditures of the stations under the Hatch Act. In this, as in other matters relating to the stations, he has been represented by the Office of Experiment Stations.

The United States Department of Agriculture, from the very beginning of its existence, has been engaged in the investigation of agricultural problems, and at the present time it employs several hundred scientists, field agents, and specialists who devote their time almost exclusively to the investigation of problems in meteorology, animal industry, plant industry, forestry, chemistry, entomology, and biology. The Department is thus primarily a great research institution, or experiment station, dealing with nearly all branches of science. It also receives from Congress funds for special investigations, with the provision that it shall as far as practicable cooperate with the experiment stations in carrying on these investigations. Notable instances of such appropriations are those for nutrition and irrigation investigations, which have been in charge of the Office of Experiment Stations; the inquiries conducted by the Office of Public Road Inquiries, and pomological, botanical, and grass and forage investigations in charge of the Bureau of Plant Industry. There is also a large amount of cooperation between this Department and the stations in other ways, including all the general lines of work in which the scientific divisions of the Department are engaged. The Department has also afforded to station officers the privileges of its laboratories, collections, and library to an increasing extent from year to year.

Agricultural experiment stations are now in operation under the Hatch Act in all the States and Territories and under special appropriation acts in Alaska, Hawaii, and Porto Rico. The stations organized under the Hatch Act are by law departments of the colleges receiving the benefit of the land-grant act of July 2, 1862, and supplementary acts relating to similar colleges established in the States which have been admitted to the Union since the passage of that act, as well as to those in the Territories. The Hatch Act, however, made an exception in favor of State agricultural experiment stations which had been established separate from the land-grant colleges prior to the passage of this act. In this way State stations are maintained in Connecticut, Louisiana, New York, and Ohio which are not connected with colleges and yet receive, in whole or in part, the benefits of the Hatch Act. In New Jersey there is a station which is supported by

State funds, as distinct from the station which receives the Hatch funds, but both stations are located at the land-grant college, and have the same director. There are also stations maintained wholly by State and local funds in Alabama, Hawaii, and Missouri, and in a number of States substations are maintained. Excluding the substations, the total number of stations in the United States is 60, of which 55 receive appropriations provided for by acts of Congress.

OFFICERS AND EMPLOYEES.

The stations which are departments of the colleges are, as a rule, under the general management of the governing boards of these institutions. The separate State stations have their own governing boards. The station staff usually consists of a director and several scientific experts in charge of special lines of work. In a few instances the president of the college is also director of the station connected with it, but in a far greater number of instances the director is a separate officer responsible to the president. There are 757 station officers in the work of administration and inquiry. The number of officers engaged in the different lines of work is as follows: Directors, 54; assistant and vice directors, 19; special agents in charge, 3; chemists, 160; agriculturists, 54; agronomists, 27; animal husbandmen, 39; poultrymen, 7; horticulturists, 79; farm and garden foremen, 39; dairymen, 34; botanists, 56; plant pathologists, 4; entomologists, 50; zoologists, 6; veterinarians, 31; meteorologists, 10; biologists, 6; physicists, 6; geologists, 4; mycologists and bacteriologists, 23; irrigation engineers, 11; in charge of substations, 16; secretaries and treasurers, 27; librarians, 12; clerks and stenographers, 34. There are also 50 persons classified under the head of "Miscellaneous," including superintendents of grounds and buildings, apiarists, herdsmen, and other employees.

INCOME IN 1903.

The total income of the stations during 1903 was $1,427,237.73, of which $720,000 was received from the National Government and the remainder, $707,237.73, from State governments, individuals and communities, fees for analyses of fertilizers, sales of farm products, and miscellaneous sources. In addition to this the Office of Experiment Stations had an appropriation of $161,000 for the past fiscal year, including $15,000 for the Alaska Experiment Stations, $12,000 for the Hawaii Experiment Station, $12,000 for the Porto Rico Experiment Station, $20,000 for nutrition investigations, and $65,000 for irrigation investigations. The total value of additions to the equipment of the stations in 1903 is estimated to be $236,370.61.

EQUIPMENT.

The stations connected with land-grant colleges have, to a large extent, been provided with land and buildings for experimental purposes by the colleges. Sometimes the land thus furnished has been definitely turned over to the stations for their exclusive use and sometimes it has remained under the control of the colleges, the stations making use of such areas as are needed for experimental purposes. (Pl. I, fig. 1.)

Most of the buildings used by the stations have been supplied by the colleges or by the States through special appropriations for their construction, and many of these are occupied jointly by the college and station. These buildings are in many cases substantial structures of brick or stone and are provided with steam heating apparatus, gas or electric lights, and often with steam or electric power for running light machinery. There are usually at each station an administration building (Pl. I, fig. 2) and chemical, botanical, bacteriological, and other laboratories, museums, and libraries. Vegetation houses are quite common, and insectaries have been erected at a few of the stations. (Pl. II, fig. 1.) The stations generally have one or more barns (Pl. II, fig. 2), and some of them have very complete equipment for experimental work in dairying. Silos of different forms are quite generally a part of the equipment of the stations, and piggeries and poultry houses are not uncommon. (Pl. III, fig. 1.) Special laboratories for experiments in particular lines, such as breeding of animals (Pl. III, fig. 2), diseases of animals, sugar making, tobacco curing, etc., have been built at some of the stations.

The stations are, as a rule, well equipped with scientific apparatus, some of which has been devised by station workers. In many instances a large amount of apparatus belonging to the different divisions of the colleges is available for the use of the station officers. The stations have made or purchased quite large collections of specimens for use in their work, especially in the departments of entomology, botany, vegetable pathology, and horticulture. They also have at their command the general collections of the land-grant colleges, which in some cases are among the most extensive in this country. Many of the stations maintain separate libraries, which usually consist of a limited working collection of reference books, scientific and agricultural journals, the publications of American and foreign experiment stations and departments of agriculture, reports of scientific associations, and miscellaneous Government and other documents on scientific and other subjects. In a number of cases books for general station workers are merged with the college library, the privileges of which, however, the station officers fully enjoy. To a limited extent also station workers are able to avail themselves of the large agricultural library of the Department of Agriculture at Washington through loans for special

FIG. 1.—NEBRASKA STATION—EXPERIMENTAL PLATS.

FIG. 2.—KENTUCKY STATION—MAIN BUILDING.

FIG. 1.—OHIO STATION—INSECTARY.

FIG. 2.—UTAH STATION—CATTLE AND SHEEP BARNS.

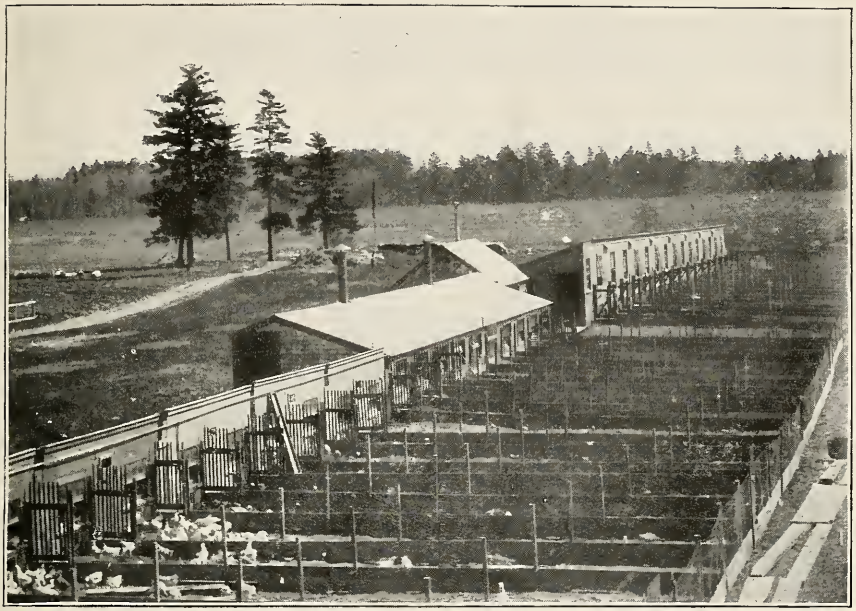

FIG. 1.—MAINE STATION—POULTRY HOUSES AND RUNS.

FIG. 2.—MISSOURI COLLEGE AND STATION—LABORATORY FOR ANIMAL BREEDING.

purposes under certain restrictions. The libraries are generally provided with card catalogues, and with the card index of experiment-station literature issued by the Office of Experiment Stations.

The business offices of the stations are provided with typewriters, duplicating machines, and other improved appliances, and filing and mailing devices. The live stock kept by the stations varies greatly with the needs of the different stations, some of which maintain considerable herds, while others procure only a few animals as they are needed for experimental purposes. It includes herds and flocks of dairy cattle, sheep, swine, horses, mules, guinea pigs, rabbits, chickens, ducks, geese, and other poultry. Most of the stations are well provided with farm machinery and implements of the latest types.

LINES OF WORK OF THE STATIONS.

Broadly speaking, the work of the experiment stations in the United States corresponds in scope and extent with the complexity of their organization. In a general way this work may be classified under the following heads: (1) Investigations involving original features; (2) verification and demonstration experiments; (3) studies of natural agricultural conditions and resources; (4) inspection and control work, and (5) dissemination of information.

It will, however, readily be understood that most of the enterprises of the stations are of a mixed character. Originality will, as a rule, be found only in some particular features of an investigation or in the adaptation of well-known facts or principles of special conditions. In the following outline the investigations of the stations which on the whole have most generally contained original features are grouped together, though in many cases they might with equal propriety be classed as demonstration experiments.

INVESTIGATIONS INVOLVING ORIGINAL FEATURES.

These investigations may be classified in a general way on the basis of the different divisions found in the organization of the stations, and comprise studies in physics, chemistry, botany, zoology (especially entomology), geology, meteorology, plant production (agronomy, including horticulture and forestry), physiology (of man and domestic animals), zootechny (animal industry), veterinary science, agrotechny (agricultural technology), including especially dairying, and rural engineering.

In most of these lines the investigations have included studies with reference to the improvement of methods of research, devising of new apparatus and appliances, the relation of scientific principles to the science and practice of agriculture, the working out of new practical applications on the basis of well-known facts and principles, or the

solution of special problems. The following statements may serve to indicate in what directions the investigations have chiefly been pursued.

Under the head of physics considerable attention has been given in recent years to studies on soils, especially as regards the methods for the physical examination of soils, the movement of soil water, and the apparatus required for such investigations.

In chemistry, the improvement of methods of analyzing soils, fertilizers, plants, foods, feeding stuffs, and other materials has occupied the attention of a considerable number of stations. This work has been done quite largely in connection with the Association of Official Agricultural Chemists. The stations have also cooperated with this association in determining food standards as a basis for the determination of adulteration. A number of pieces of special chemical apparatus have been devised. A very large number of analyses of economic plants, foods and feeding stuffs, dairy products, fertilizers, and other agricultural materials, especially those distinctively American, have been made for the first time in the chemical laboratories of the stations. A considerable number of purely chemical investigations have been conducted, such as the isolation of different proteids and their examination as to properties and elementary composition; studies of the development of the constituents of crops during growth and storage; investigation of the constituents of the nitrogen-free extract of feeding stuffs; a study of the status of phosphorus in vegetable and animal feeding stuffs; an investigation of the chemical changes taking place in cheese during the process of ripening; studies of the composition of crops as influenced by environment; and systematic chemical studies of a considerable number of staple crops, such as alfalfa, corn, cotton, tobacco, and wheat. Chemistry has, however, usually been an adjunct to investigations along various lines of plant and animal production. For instance, the composition of corn has been thoroughly investigated, the object being to increase the protein and oil content by selection and crossing.

In botany considerable systematic work has been done, especially in the newer States. New species of useful and injurious plants have been discovered and described; herbaria of the economic flora of individual States have been collected, and new light has been thrown on the botanical relations of species of economic plants. The botanical work of our stations has, however, been most largely along the lines of vegetable physiology and pathology and bacteriology. The studies in vegetable physiology have included investigations of special problems and the devising of methods and apparatus for such studies. In vegetable pathology much has been done in working out the life histories of fungi injurious to cultivated plants and in devising methods and apparatus for the repression of diseases of plants. The bacterio-

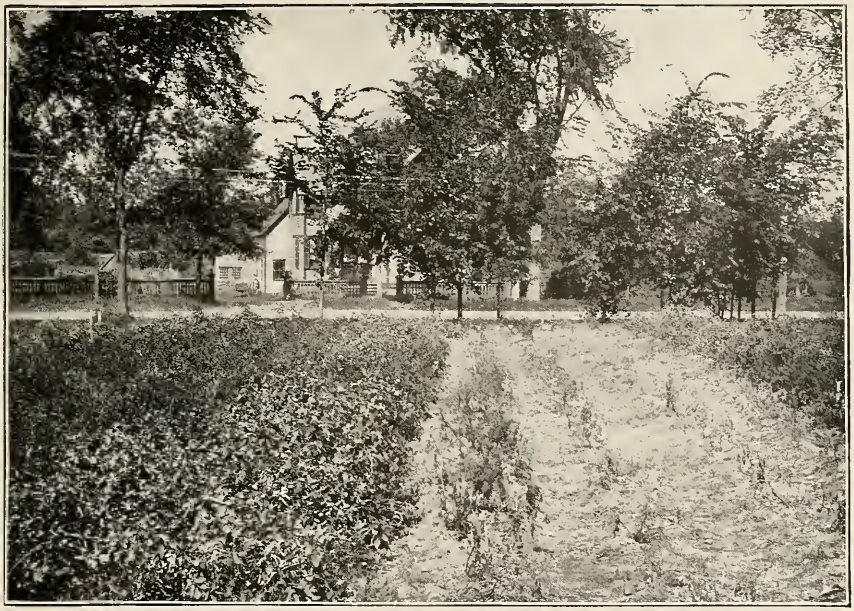

FIG. 1.—VERMONT STATION—SPRAYED AND UNSPRAYED POTATOES.

FIG. 2.—TENNESSEE STATION—COWPEAS AND SORGHUM FOR SILAGE.

logical work of the stations has included the isolation, culture, and description of many species of useful and pathogenic bacteria in air, soil, fertilizers, plants, food, feeding stuffs, and other agricultural products, and those affecting useful and injurious animals. Methods and apparatus for bacteriological investigations have been devised, and means for the repression of pathogenic bacteria have been worked out. Among the diseases of plants which have received most attention at our stations are those affecting potatoes (Pl. IV, fig. 1), cotton. cereals (especially smuts), sweet potatoes, beans, celery, grapes, and pears (especially blight).

Among investigations in vegetable physiology which have been undertaken by the stations, mention may be made of those on the cause and prevention of sun scald of fruit trees, the effect of arc and incandescent electric lights on plant growth, and the influence of various forms of electricity on seed germination, and the influence of various enzyms upon the germination of old seeds of various kinds. Investigations have also been conducted upon the effect of alkali upon germination. Again, extensive series of investigations have been made on the flow of maple sap. The distribution of the roots of different plants in the soil has been studied at several stations. Weed distribution, propagation, seedlings, seeds, etc., have been studied by numerous station botanists.

In zoology by far the most important work of the stations has been along the lines of economic entomology. This has included the collection of large numbers of specimens of insects; the description of new species, and the working out of their life histories; studies in the breeding of insects, especially as a means for their investigation: the discovery of methods and appliances for the repression of injurious insects, and for the study of insects. Among the insects on which the station entomologists have made extensive studies, resulting in the development of effective methods for their repression, are the following: The codling moth, plum curculio, San José scale and other scale insects, chinch bug, Rocky Mountain locust, woolly aphis, cotton worm, boll weevil, forest insects, and insects affecting stored grains. In other lines of zoological investigation systematic and other studies have been made of injurious mammals (especially gophers, prairie dogs, rabbits, and woodchucks) and birds. There have also been special investigations relating to oysters and nematodes.

Under the head of agronomy a large amount of work has been done in the introduction of new varieties of crops and in the improvement of varieties by selection and breeding. Fertilizer and tillage experiments have been conducted, drainage and irrigation problems investigated, and methods of harvesting and storage studied.

Many of the crop introductions have been made by the United States Department of Agriculture, while their general use has been

accomplished largely through the cooperation of the stations. Thus Kafir corn has been found a most valuable drought-resistant forage and food plant in regions of the Southwest where maize is an uncertain crop, and the macaroni wheats are greatly extending the area of profitable wheat production in the semiarid regions. In the same way the adaptability of different parts of the United States to the culture of beets for sugar has been definitely established. The introduction and increased culture of grasses and leguminous plants for forage and green manuring, especially in the Southern States (Pl. IV, fig. 2), promises to become a factor of far-reaching importance in the agricultural development now taking place in those States. The rape plant has been successfully introduced in a number of States as an adjunct to sheep husbandry, and alfalfa has been shown to be a useful and successful crop in many regions where it was not formerly grown. The improvement of wheat by selection and cross breeding has resulted in the establishment of varieties of wheat of better milling qualities and increased yield. Similar experiments with other cereals, flax, sugar cane, sorghum, cotton, and grasses are in progress. Experiments for the increase of the protein and oil content of maize are being conducted with promising results.

The experiments with fertilizers have included tests of a large number of different forms of commercial fertilizers and farm manures for different crops, the kind of plants best adapted to green manuring and the methods of their management, the forms of fertilizers (e. g., potash salts) best adapted to the production of high quality in the product, the application of fertilizers to hasten growth and prolong ripening, the rendering of fertilizing material (e. g., leather refuse and fish) available to plants, and the economic utilization of refuse materials (e. g., seaweed) for fertilizers.

Tillage experiments with the farm crops have included deep and shallow cultivation, frequent cultivation, subsoiling, fall and spring plowing, summer fallowing, planting winter catch crops, turning under green crops. In this connection thick and thin seeding, planting at different depths, use of light and heavy seeds and seeds from different parts of the fruit, distance experiments, intercultural experiments, and the growing of crops (especially tobacco) under shade have been tried.

Irrigation problems in arid regions have been investigated with special reference to the amount of water required for various crops, the effects of applying water at different stages of growth, and the best methods of applying water and of preventing losses from ditches. In semiarid and humid regions the cost and methods of securing water and the profits from its use have been studied, as well as methods of use.

There have also been investigations in the harvesting of wheat, oats, and barley at different stages of growth and at different periods of

FIG. 1.—TENNESSEE STATION—LETTUCE UNDER GLASS.

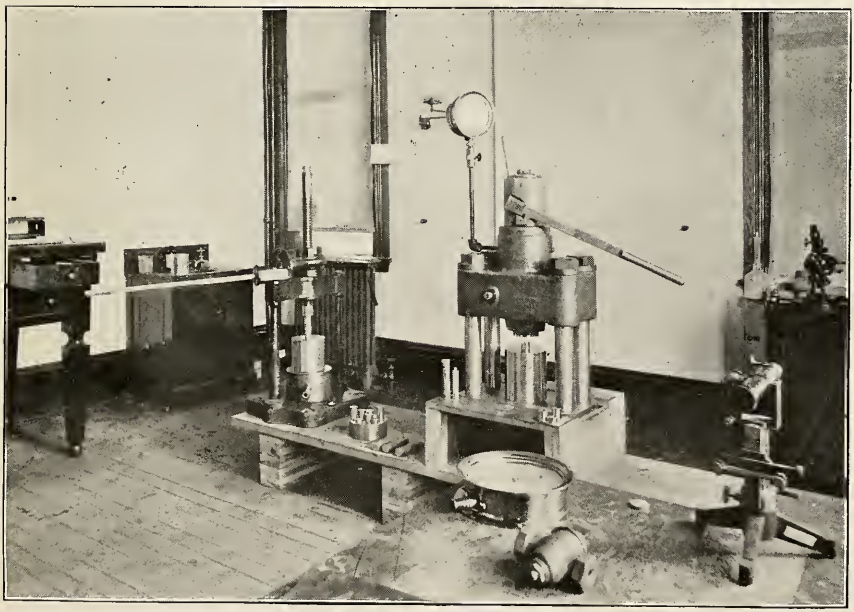

FIG. 2.—WEST VIRGINIA STATION—APPARATUS USED IN EXPERIMENTS IN PRESERVING MILK UNDER PRESSURE.

ripening; curing of hay at different stages of development; the economy of different methods of harvesting maize; the shredding of maize stalks, and the storage of maize as silage. Much valuable work has been done on the curing, fermenting, and storing of tobacco. Investigations of harvesting sugar cane at different times, both before and after freezing, have given valuable results.

In horticulture most attention has been given to testing the adaptability of varieties to different regions. In addition to this there have been studies of the selection and breeding of horticultural plants and the methods of culture, grafting, and pruning. Considerable attention has been given to questions relating to the growing of horticultural plants under glass, including the construction of houses, heating, irrigating, manuring, culture, etc. A leading feature of the horticultural work has been that with orchard fruits on a commercial scale. Valuable introductions of new and hardy fruits have been made. Native fruits have been studied and improved and wild species brought under cultivation. The Japanese plums have become widely distributed as far north as Michigan and are the most valuable fruit introduction of recent years. Native plums have been studied and nearly three-fourths of the present 200 named varieties brought into cultivation within the life of the experiment stations. Careful work has been done in the selection and cross breeding of native varieties of grapes. Superior varieties for certain localities have already been obtained. Dewberries, juneberries, and sand cherries are other native fruits which have been brought under cultivation and made permanent features of our fruit resources. Among the important fruit introductions may be noted the date palm, which is found to be well adapted to some localities in the Southwest. The introduction of the Japanese persimmon and the improvement of our native varieties by selection and grafting seem likely to result in placing this fruit among the permanent orchard crops of certain Southern localities. Extensive investigations of Russian fruits have been made. The unfruitfulness of many varieties of orchard fruits has been shown to be due to self-sterility.

The winter forcing of vegetables has become a profitable commercial industry (Pl. V, fig. 1). Combinations of forcing-house and field methods of culture of a number of American garden crops have been introduced. This has proved especially valuable in the culture of onions. The value of irrigation as a feature of truck gardening and fruit growing in humid regions, and of subirrigation in greenhouses with certain forcing crops, has been thoroughly demonstrated. Fertilizer experiments with numerous horticultural crops have thrown much new light on the subject of intensive manuring. The utilization of fruits, more especially the unmerchantable fruits, in the making of

jelly, preserves, fruit sirups, and cider has been investigated and valuable suggestions given to this industry. Some of the stations have given considerable attention to the beautifying of home and school grounds by the introduction of ornamental trees, shrubs, flowers, etc., not previously used in their localities.

The forestry work of our stations has been principally confined to the testing of different varieties of trees with reference to their adaptability to particular regions and problems connected with the reforesting of our treeless regions.

In the physiology of man and the domestic animals the work of the stations has been largely along the line of nutrition. The most important piece of work in this line has been the devising of a special form of respiration calorimeter for experiments with men in which the Storrs Experiment Station in Connecticut has cooperated. This calorimeter has now been adapted to investigations with domestic animals at the Pennsylvania Experiment Station. The experiments with the respiration calorimeter already made with men have brought strong evidence that the law of the conservation of matter and energy holds good in the animal body and have added important data to our knowledge of other laws of nutrition. Other studies have had to do with the substituting value of different nutrients and the proper combination of nutrients in the diet. Many dietary studies have been made with men and animals, under different conditions and performing different amounts of work, in various regions of the United States. A number of stations have made digestion experiments with men and animals, and as a result the coefficients of digestibility for a considerable number of American foods and feeding stuffs have been determined. Many metabolism experiments have been made with men and farm animals. In most of the experiments the balance of income and outgo of nitrogen has been determined; in a smaller number the balance of carbon or carbon and energy has also been determined, and in a few cases the balance of ash or certain ash constituents has also been studied. Very extended studies have been made of the composition of beef, mutton, poultry, and pork produced under different conditions. The effect of cooking on different foods and the losses during cooking have also received attention. Physiological studies of digestibility and digestive ferments and of the milk glands have been undertaken. Much time has been devoted to the elaboration of experimental methods, the testing of methods already known, and the devising of new methods.

The work in zootechny (in the restricted sense of animal production) has principally consisted of feeding experiments with farm animals, in which various combinations of feeding stuffs have been tested with reference to maintenance, growth, or the production of meat or milk (Pl. V, fig. 2). In this way the nutritive value of a large number of

feeding stuffs has been worked out, largely on a practical basis. Important studies have been made on the nutritive value of crops of recent introduction or crops which have recently assumed importance, such as alfalfa, rape, and Kafir corn. Many feeding experiments have been made with silage made from a single crop cut at different stages of growth and from mixtures of two or more crops; also many studies of the feeding value of milling products and by-products, and studies to determine the cause of cotton-seed poisoning, the cost of producing meat or milk, and the proximate cost of rearing young animals. Many studies have been made with poultry, including the effect of different rations on egg production, tests of incubators, and the breeding, feeding, and marketing of geese.

Digestion experiments have been conducted with horses, cattle, sheep, goats, and pigs. Attempts have been made at several of the stations to formulate feeding standards more suitable for American conditions than the German standards commonly in use. Tests of breeds of different kinds of animals have also been made, sometimes on a relatively large scale, and studies of types of animals best adapted to particular purposes have in some cases been made. The studies in zootechny have, to a considerable extent, been connected with the investigations in animal physiology.

The stations have taken up under veterinary science the studies in bacteriology above referred to, and investigations regarding the causes, nature, and treatment of various diseases of domestic animals. The subjects to which most time and attention have been devoted include anthrax, Texas fever, hog cholera, swine plague, sheep scab, mange of cattle and horses, tetanus, milk fever, rabies, glanders, colic of horses, infectious abortion, actinomycosis, foot-and-mouth disease, and tuberculosis; dehorning; spaying; effects of poisonous plants, including the effects of smuts, ergot, and mildews on fodder; and the relation of water supply to diseases.

In agrotechny (agricultural technology) the most important work of the stations has related to dairying. Besides the chemical and bacteriological studies of milk and dairy products, referred to under the head of chemistry and bacteriology, the stations have made many studies relating to the methods of manufacture of dairy products.

Under the head of dairy bacteriology the studies have included the extent and sources of infection of milk, means of avoiding infection by cleanly methods and by pasteurizing and sterilizing, the use of pure cultures for ripening cream in butter making, and the nature and cause of the changes in the ripening of cheese.

The business relations between the milk producer and creameries or cheese factories have received attention. Various kinds of dairy and creamery apparatus have been tested to a considerable extent, and in

some cases demonstrations have been made of the method of conducting a hygienic dairy and milk route. Nearly every step in the handling of milk and in the manufacture of butter and different kinds of cheese has been investigated. In this connection considerable work has been done in studying methods of investigation and devising special apparatus and appliances for such work.

Other important investigations in agricultural technology have been those in sugar making; the pickling of olives; the manufacture of unfermented grape juice, wine, olive oil, cane sirups, fruit sirups, cider, and maple sugar; the evaporation of fruit and vegetables, and the preservation of fruit and milk under pressure. In these investigations the devising of new methods of manufacture and special apparatus and appliances has received large attention.

The American stations have as yet given comparatively little attention to problems in rural engineering, but are now undertaking more work along that line. Studies of the form and construction of barns, silos, and other farm buildings have been made, as well as of the construction and heating of greenhouses and the construction of cold-storage plants and cheese-curing rooms. Questions relating to methods of drainage, irrigation, road making, and the construction of dams, canals, ditches, and other irrigation works have been studied. The draft of farm vehicles, especially as related to the comparative merits of broad and narrow tires, has been tested. A considerable number of practical tests have been made of implements and machinery used on farms or in dairying, including windmills and engines for pumping and grinding.

VERIFICATION AND DEMONSTRATION EXPERIMENTS.

A considerable share of the work of American stations has thus far consisted of the verification of results obtained elsewhere and the demonstration of the practical usefulness of these results. This work has been partly carried on at the stations and partly in different localities, largely in cooperation with farmers. It has included a wide range of subjects along most of the lines in which the stations have attempted more original investigations, such as experiments with fertilizers, tests of methods of cultivation, and practical tests of different field crops and horticultural plants, the adaptability of which the stations have determined on a small scale.

Many of the experiments in the feeding of animals and in dairying have been made by the stations for the purpose of confirming the results obtained through previous investigations. Often the chief purpose of these investigations has been to convince farmers that the results which have been obtained elsewhere were equally applicable to their local requirements. In a similar way many investigations in chemistry, botany, entomology, and veterinary science have been

repeated either for the purpose of verifying the correctness of the results previously obtained or of demonstrating their practical application. Thousands of such experiments are now annually conducted in cooperation with farmers; and while it is clearly recognized that many of them are very imperfectly carried out, yet it is believed that they have been a very important element in the success of the stations.

Without doubt there has thus far been considerable duplication of work by the stations; but when we consider the wide agricultural areas for which many of our individual stations work, the varying natural conditions in the different States, and the comparative unfamiliarity of our farmers with the results of agricultural investigations, it will be realized that whatever incidental losses there have been through unnecessary duplication of work on the part of the stations have been more than overbalanced by the benefits which have accrued from a repetition of investigations until their results have been verified under a variety of conditions and have become a part of the farm practice.

STUDIES OF NATURAL AGRICULTURAL CONDITIONS AND RESOURCES.

Closely related with the demonstration experiments of the stations have been those studies which have had for their main object the gaining of definite information regarding the natural agricultural conditions and resources of the different States. While our stations were not established for the making of agricultural surveys or the collection of agricultural statistics yet in many cases, especially in the newer States and Territories, the absence of accurate information has made it necessary for the stations to do more or less work of this character as a preliminary to the scientific investigations and practical experiments which it is their real business to make. In this category may be included the collection of general meteorological data, studies of geologic formations, soils, water supply for household use, for live stock, or for irrigation, botanical surveys, and studies of life zones and the suitability of varieties of crops to these zones. The largest enterprise of our stations which may be said to have been essentially a study of the natural agricultural conditions has been the determination of the regions in which sugar beets may be grown with a sufficiently high percentage of sugar to make it probable that they might be utilized in sugar making, provided the economic conditions were favorable. This investigation was carried on by the stations very largely in cooperation with the United States Department of Agriculture and farmers. Thousands of experiments were made for several years, covering the entire country, and in this way the capabilities of the United States with reference to the growing of sugar beets were quite definitely established.

INSPECTION AND CONTROL WORK.

The experiment stations in 36 States and Territories are doing more or less work of inspection, either under special State laws or as a voluntary enterprise. The nature and amount of this service varies greatly in different States. Sometimes the station conducts a complete inspection and control, sometimes it makes the chemical or other examinations for some other organization which exercises the control, or it may simply make the examinations and publish the results for the information of the public, no system of control being provided by law. The fertilizer inspection was the first line of station work established in this country, is most thoroughly organized, and is most intimately connected with the other work of our stations. More recently inspection of dairy products and other foods for man has been undertaken in a number of States and the stations have been called upon in various ways to promote this work. In some of the Eastern States, where concentrated feeding stuffs are largely used, laws for their inspection by the stations have been enacted within the past few years. Inspection for the prevention of diseases of animals and plants and the repression of injurious insects and weeds has been begun in a number of States. Dairy apparatus and Paris green are required to be inspected in a few States, and there has been considerable voluntary inspection of seeds by the stations in different parts of the country.

The Hatch Act makes no provision for regular inspection work by the stations. The stations supported exclusively by this fund have therefore undertaken such work only incidentally with a view of showing its usefulness. Wherever it has assumed importance and the necessity for its regular performance has been made apparent, the States have made provision for its maintenance.

DISSEMINATION OF INFORMATION.

The Hatch Act requires that each station shall publish bulletins or reports of progress at least once in three months, and a full and detailed report of its operations, including a statement of receipts and expenditures, once a year. Most of the publications of the stations may therefore be divided into two general classes—annual reports and bulletins.

The annual reports of the stations vary greatly as regards the character of their contents, their size, and the number of copies printed. In a number of States the annual report is a large document containing detailed statements regarding the administration, finances, and investigations of the station; in some States it is a brief document containing only short statements regarding administrative matters, finances,

investigations, and publications, and in others it contains an administrative report and all the bulletins issued by the station during the year. In a number of States the annual report is printed at the expense of the State. The annual report may be sent out to the entire mailing list, or it may have a very restricted distribution to educational institutions, experiment stations, libraries, officials, and individuals known to be specially interested in the details of station administration. The Hatch Act provides that this report shall be made primarily to the governor of the State or Territory in which the station is located, and that a copy shall be sent to each of the experiment stations, to the Secretary of Agriculture, and to the Secretary of the Treasury of the United States.

The bulletins of the stations are of different descriptions and can not be definitely separated into classes. All of the stations have, however, a regular series of bulletins, usually numbered consecutively, which comprise the greatest part of their publications. These bulletins contain a great variety of information. Some of them consist wholly of compiled matter, some are popular accounts of station investigations, and others contain quite technical and elaborate descriptions of their investigations. Some stations have attempted to separate their technical and popular bulletins into different series, and in some cases new series have been begun after the station has been in operation a number of years. As a rule, however, the stations issue their regular bulletins in a single series. Many of the stations annually issue more than the four bulletins required by the Hatch Act. The number of annual reports and bulletins published by the stations in 1903 was 371. The bulletins are sent out to mailing lists containing from 2,500 to 43,000 addresses, the aggregate number of addresses being about 621,000. The stations endeavor to send their bulletins to all applicants within their own States and to satisfy outside demands for them as far as their means will allow. This outside demand has, however, grown to be so large as already to cause embarrassment. Each station has a considerable number of foreign correspondents to whom the bulletins are regularly sent.

In a number of the States the stations prepare press bulletins, river bulletins, postal-card bulletins, hints to farmers, etc., which are either résumés of the station work or contain information of more general character. In cases in which the station receives a large number of requests for information on any topic, it has been often found convenient to have answers distributed through the press or by means of emergency bulletins rather than by correspondence.

At the New York State Station a special officer is employed to edit the publications of the station, and one of his duties is to prepare brief, popular bulletins based on the longer and more technical publications of the station. These popular bulletins are sent to the mailing

list generally, which in that State numbers 42,000 addresses, while the larger publications are issued in more restricted editions.

Some of the stations have from time to time issued charts and posters illustrating special features of their work. Some of these have been made up in the same manner as advertising posters, with illustrations and display type. Such posters are placed in railroad depots, post-offices, and other public places where they will attract the attention of farmers who are not already familiar with the work of the station.

The attendance of station officers at farmers' institutes and other meetings of farmers is another means of disseminating the results of their investigations, and this method is especially valuable in reaching farmers who do not read the station publications.

The correspondence carried on by station officers is very large, aggregating hundreds of thousands of letters annually. A large part of these are replies to inquiries by farmers, which cover almost every topic related to the theory and practice of agriculture.

A considerable number of stations make exhibits of their work at State and other agricultural fairs.

GENERAL RESULTS OF THE WORK OF THE STATIONS.

During the past fourteen years the expense of operating the experiment stations in the United States has amounted to $14,000,000, an average of $1,000,000 a year. This is equivalent to a tax of $1 on each $20,000 worth of farm property in the United States—not a very heavy burden, and yet sufficiently heavy to justify careful supervision of expenditures and an occasional inquiry into the value of results attained.

While it is a well-known and generally accepted fact that many of these results are of great economic importance, it is extremely difficult to estimate the cash value of them. In a general way, however, an idea can be given of the value of some of the more important and striking results. Thus the investigations of the stations have revolutionized and developed the dairy industry, and the total value of dairy products in 1899 amounted to $472,000,000. Closely connected with the improvement of dairying have been the investigations on nutrition, which have widely changed the practice of feeding farm animals. One very important result of investigations along this line has been the demonstration of the feeding value of corn stover and other by-products of corn, wheat, cotton, and other farm crops. It is estimated that the feeding value of corn stover is not less than $100,000,000 per annum and that the combined feeding and fertilizing value of cotton seed is $150,000,000. The stations have shown that cheese can be cured in cold storage with resulting improvement in the quality and a

vast saving on the annual product valued at $300,000,000. Similarly their experiments in the cold storage of fruits are giving results of great economic importance. They have also contributed greatly to the success of growing vegetables and flowers under glass. The commercial greenhouses in 1900 covered over 22,000 acres.

The improvement of farm crops by breeding and selection and the introduction of new crops are items of great importance in estimating the success of the stations. It is estimated that the general use of improved strains of wheat developed by the stations would increase the total annual yield of this cereal over 50,000,000 bushels, and that in the same way the yield of oats might be increased 30,000,000 bushels. The introduction of Manshury barley by the Wisconsin Station has been worth millions of dollars to the farmers, and the Kafir corn brought in by the United States Department of Agriculture, but introduced to practical use by the stations in California, Kansas, and Oklahoma, was valued at over $5,000,000 in Kansas alone in 1899. Other valuable introductions made in the same way are sugar beets, estimated at $6,000,000 in 1901, and macaroni wheats, worth $4,400,000 in 1903. The stations have promoted the general use of alfalfa, the product in 1899 amounting to over 5,000,000 tons.

The investigations on fertilizers have not only served to protect farmers from fraud, but have led them quite generally to recognize the desirability of a discriminating use of fertilizers. It is estimated that if farmers generally would practice home mixing of fertilizers, as many of them have been taught to do in New Jersey and some other Eastern States, a saving of $13,500,000 per annum would result in this one item of farm expenditures. The work of the stations in combating the diseases and insect pests of plants and animals has been of inestimable value to the farmers. In many lines it has made all the difference between success and failure. Without systematic use of insecticides and fungicides—largely worked out by the stations—commercial orcharding would be impossible and a source of income worth $84,000,000 a year to American farmers would speedily disappear.

The examples cited above are merely samples of what the stations have done for the American farmer. There are thousands of other results, less palpable, perhaps, but just as far-reaching in their influence. No account has been given of the educational influence of the stations, which is even more important than this other work. They have been a powerful aid in breaking down the popular prejudice against agricultural colleges and the whole scheme of agricultural education; have furnished the material for the formulation of a science of agriculture, and have done much to place agricultural courses on a par with other courses in work for advanced degrees.

As regards the stations themselves, we may confidently assert that their past history gives great assurance of increasing strength and

efficiency in the future. While they have encountered many difficulties in their development, and there has necessarily been much of crudity in their work thus far, they have every year secured a better equipment and more thoroughly trained officers. With increasing resources they have been able to specialize their work more thoroughly and to increase its scope. They have succeeded in securing, to a remarkable extent, the confidence of the people for whose benefit they were primarily established, and have thus had no difficulty in obtaining financial support from Congress and the State legislatures. The people generally have come to regard the stations as permanent institutions, and are convinced of the usefulness of their work.

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